United States
Department of
Agriculture

Animal and
Plant Health
Inspection
Service

Plant Protection
and Quarantine

New Pest Response Guidelines

BROWN CITRUS APHID
Toxoptera citricida

This PPQ Action Plan or New Pest Response Guideline has not been updated since its publication date. The actions or guidelines recommended may not be appropriate now, new survey tools may be available, and chemical pesticides named may no longer be registered. This documents is posted until updated versions can be drafted and as such are only guidelines that represent the state of knowledge at the time they were written. Please consult PPQ and/or your State Plant Regulatory Official prior to implementing any recommendations listed herein.

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PURPOSE

This New Pest Response Guidelines provides guidelines and actions for mitigating the impact of the Brown Citrus Aphid (BCA), Toxoptera citricida.

It is to be used as an aid for States when developing State action plans. The procedures described in this New Pest Response Guidelines were developed by Program Review and Planning Staff through discussion, consultation, or agreement with other Animal and Plant Health Inspection Service (APHIS) staff, Cooperating States, Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), and affected industry.

Disclaimer

This document is not intended to be complete and exhaustive. The information given herein was taken from some of the available literature and synthesized into a specialized paper intended to assist further work, as given above. Some key articles were not available at the time this was written, nor have pertinent specialists and other members of the research community been consulted for their advice.

I. GENERAL INFORMATION

A. Action Statement

The information contained in this document is intended for use as guidance in designing a program to detect and respond to a Brown citrus aphid (BCA), Toxoptera citricida (Kirkaldy), infestation. This New Pest Response Guidelines provides information on implementing detection and control procedures for BCA and in reducing or suppressing its spread to other locations. It provides technical and general information needed to implement any phase of a BCA detection, control, containment or eradication program. Specific emergency program action is to be based on information available at that time.

B. Background Information

The BCA is native to China. It is now known throughout the tropical citrus growing areas of Asia, Africa, Australasia, the Pacific islands, Central and South America and the West Indies (Denmark, 1978).

This pest was rated as number 1 of the 5 most important insects in Rhodesia (Africa) in 1925. From 1936 to 1946, Brazil lost 7 million orange trees in the State of Sao Paulo, due to its importance as a vector of Citrus tristeza virus (CTV). It is responsible for premature decline of grapefruit in South Africa and Australia and is a limiting factor in small sour lime production in West Africa. Severe damage is also reported from Formosa, Mauritius, New Zealand and other areas (Denmark, 1978). In China, BCA is a vector of soybean mosaic virus (SMV) (Halbert, 1986).

C. Life Cycle Information

BCA development is temperature dependent. Egg, nymphal and adult development are influenced by air temperatures. Development may also be influenced by the host. There is a minimum threshold below which no measurable development takes place. For BCA, this threshold on Citrus aurantium (Sour orange - chosen because this rootstock is common in the United States) is 47.15 °F (8.4 °C) in air (Komazaki, 1982). A temperature model that is designed to use modified air temperature data for all insect stages can be used to predict the entire life cycle. A number of degrees accumulated above the developmental threshold for a life stage are called day degrees. One day degree is one day with the average temperature one degree greater than the threshold for development.

For the model depicted in the table below, 257 (125 in Celsius) day degrees must be accumulated before one life cycle has been completed (Komazaki, 1982).

Day Degree Calculations

Formula:

Minimum Daily		Maximum Daily		Total		Average Daily		Threshold		Day Degrees
Temp °F	+	Temp °F	=	$\frac{\text{Temp °F}}{2}$	=	Temp °F	-	Temp °F	=	# of DD

Example: (Air Temperature Model with 47.15 °F Threshold on sour orange)

Minimum Daily		Maximum Daily		Total		Average Daily		Threshold		Day Degrees
54 °F	+	74 °F	=	$\frac{\text{128 °F}}{2}$	=	64 °F	-	47.15 °F	=	16.85 DD

Program actions are governed in part by insect life cycle data. Control and/or eradication treatments, length of survey activities, and regulatory functions are affected primarily by the length of time it takes to complete the life cycle. Temperature data are available from the National Oceanic and Atmospheric Administration, the U. S. Department of Commerce, private, State, university, or industry sources, or from remote site weather monitoring stations run by any of the above. Unforseen delays in completion of the life cycle must be anticipated.

II. SURVEY PROCEDURES

A. Detection Survey

Cross Transit Surveys are recommended for a rapid detection survey for the BCA (Stibick, 1992). It will also be used in support of a delimiting survey. The survey proposed here is biased towards the primary host of concern, citrus, and in areas where the aphid, if introduced, might be expected to be found first. Owing to the possibility of air dispersal; a special survey may be warranted for certain downwind areas.

There are three types of areas to cover in this survey:

- <u>High Risk Areas</u>

Major cities and towns where residents and visitors may be expected to travel to and from areas where the BCA already exists.

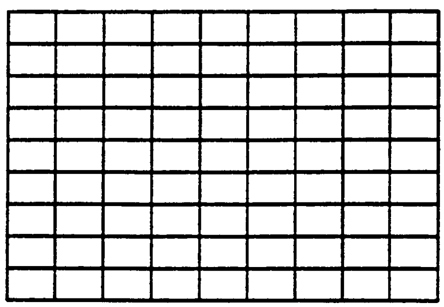
- <u>Windward Areas</u>

Those areas where winds may reasonably be expected to carry the BCA from areas where it already exists.

- <u>Citrus Production Areas</u>

B. Delimiting Survey

When one or more BCA are collected in an area, a delimiting survey will be implemented immediately to determine the population distribution. Using the site of the detection as the epicenter (focal point), the survey will employ the following methods and traps to delimit the extent of the infestation.



Core Area: 1 sq. mile

Epicenter: (Focal Point)

↑
1 sq. mile

———81 Square Miles———

1. Cross Transit Survey

Cross Transit Surveys are recommended for a rapid delimination survey for the BCA when a find is verified or suspected. The objective is to find and delimit the infested area in the shortest possible time, with minimum labor and expense, but with a high degree of confidence that if present, it will be found.

The survey proposed here is biased in the same way as it is for the detection survey. It is biased towards the primary host of concern, citrus, and in areas where the aphid, if introduced, might be expected to be found first. Owing to the possibility of air dispersal; a special survey may be warranted for certain areas.

There are three types of areas to cover in this kind of survey:

- <u>High Risk Areas</u>

  Major cities and towns where residents and visitors may be expected to travel to and from areas where the BCA already exists.

- <u>Windward Areas</u>

  Those areas where winds may reasonably be expected to carry the BCA from locations where it already exists.

- <u>Citrus Production Areas</u>

2. Block Survey

If a find is verified and the cross transit survey indicates the infested area is small and perhaps well defined:

- Conduct a block to block survey in the suburban/urban areas up to 7.2 km (4 1/2 miles) from each find.

- In rural areas, conduct a property by property survey up to 7.2 km (4 1/2 miles) from each find.

- Each block or property can be scored, if BCA is present, as:

  - Light--1 to a few BCA only on one or a few hosts (of any combination of host species).

- Medium--Moderate numbers of BCA on 6 or more hosts (of any combination of host species).

- Heavy--Entire area with numerous BCA on numerous plant hosts (of any combination of host species).

The above will permit the project to more accurately plot the area, extent, and nature of the infestation.

The frequency of the delimiting survey will depend on the time it takes to cover the area, the resources available for repeat surveys and if a decision is made to eradicate BCA. A maximum interval would be one month between surveys.

C. Monitoring/Evaluation Survey

A decision to suppress or eradicate the BCA will require a monitoring/evaluation survey to check on the wild BCA population. Generally, a cross transit survey would be employed.

D. Orientation of Survey Personnel

New personnel will be trained on the job by experienced personnel.

E. Survey Records

Records noting the areas surveyed, sites trapped, dates, locations, and hosts in which detections were made will be maintained.

III. REGULATORY PROCEDURES

A. Instructions to Officers

Regulatory actions will be required until the pest is eradicated or declared established with no further suppression or control actions. Officers must follow instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles. Understanding the instructions and procedures will serve as a basis for explaining such procedures to persons interested in moving articles affected by the quarantine and regulations. Only authorized treatment procedures may be used.

General instructions that are to be followed in regulatory treatments may be found in State regulatory manuals or in the PPQ, APHIS, Treatment Manual (PTM).

B. Regulated Articles

A variety of articles may present direct or indirect risks of spreading BCA. The movement of these articles will be regulated to prevent the infestation from spreading. Regulated articles include:

1. Fresh leaves and stems of hosts listed in Addendum C which exist in the regulated area (Reeves, 1992).

2. Nursery plants or other material with leaves and stems, including propagative material intended for planting.

3. Any other product, article, or means of conveyance of any character whatsoever when it is determined by an inspector that it presents a hazard of spread of the BCA and the person in possession thereof has been so notified.

C. Quarantine Actions

Regulatory action will be required if:

1. One adult, apterous or alate female or a nymph is found at any time. (Males will almost certainly not be available and definite identification may not be possible.)

When detections are made, the following steps should be taken:

a. State notifications are issued by field personnel to the property owners or managers of all establishments within 4.5 miles of the epicenter that handles, moves, or processes host material which may include material and/or conveyances capable of spreading the BCA. Notifications will be issued pending authoritative confirmation and/or further instructions from the Head of the State Plant Protection Service and/or the Deputy Administrator, APHIS, PPQ.

b. If necessary, the Deputy Administrator will issue a letter directing PPQ field offices to initiate specific emergency action under the Federal Plant Pest Act (7 U.S.C. 150 dd) until emergency regulations can be published in the Federal Register. For information on other legal authorities, see Section II, Parts A and B of the APHIS Emergency Programs Manual (for plant pests).

c. The Head of the State Plant Protection service and/or The Deputy Administrator of APHIS will notify other State cooperators of the BCA detections, actions taken, and actions contemplated.

d. A narrative description of the regulated area with supporting documents will be developed by State personnel. The regulated area will normally be within an approximate 4 1/2 mile (mi) radius around the find, and may contain a 1 sq. mile (mi) or greater core area where premises may be treated.

e. The State will publish an interim rule covering the emergency regulations. The interim rule will announce a date for submitting written comments.

f. After receipt of written comments, a final determination specifying the action decided upon will be published.

D. Regulated Establishments

Efforts to detect the pest within the regulated area will be made at establishments where host material is sold, handled, processed, or moved. Establishments that might be involved include airports, landfill sites, fruit stands, farmer's markets, produce markets, flea markets, nurseries, and any other establishments that handle host material.

E. Use of Authorized Chemicals

The appropriate state manual and this New Pest Response Guidelines identify chemicals authorized for BCA control, methods and rates of application, and any special application instructions. Concurrence by the appropriate State regulatory Agency is necessary for the use of any other chemical or procedure for regulatory purposes.
If treatments selected or proposed, including those listed in this New Pest Response Guidelines, are not in compliance with current pesticide labels, emergency exemptions will need to be obtained under Section 18, or 24C, Special Local Need (SLN) of FIFRA, as amended. Regulated articles may be certified for movement after treatment.

F. Approved Regulatory Treatments

1. Sanitation. The removal and destruction of leaves and stems and other host material which may be associated with these regulated items.

2. Steam Sterilization. The use of live steam as a treatment alone, to conveyances, storage, or other holding areas.

3. Cleaning. The use of hot soapy water as a treatment alone, to conveyances, storage or other holding areas or to host material to destroy any life stages of BCA present.

4. Fumigation. The application of an approved fumigant (methyl bromide) as a treatment alone, to hosts.

5. Hot Water. The application of hot water at a specified temperature, as a treatment alone, to hosts.

6. Ground Spray. An approved insecticide or biological insecticide applied to the above-ground parts of nursery stock.

7. Soil Treatment. An approved insecticide applied to the soil of nursery stock.

G. Principal Activities

The following identifies principal activities necessary for conducting a regulatory program to prevent the spread of the BCA. The extent of regulatory activity required is dependent on the degree of infestation. For example, to safeguard fruit stands throughout the entire regulated area when these stands are only engaged in local retail activity may not be necessary during a localized and light infestation. On the other hand, mandatory checks of passenger baggage at airports and the judicious use of road patrols and roadblocks may be necessary where general or heavy infestations occur.

Principal regulatory activities include:

1. Contacting and advising regulated industry of regulations and required treatment procedures.

2. Issuing compliance agreements, certificates and permits.

3. Supervising, monitoring, and certifying treatments of host material.

4. Conducting compliance inspections at regulated establishments such as:

a. Nurseries
b. Fruit stands
c. Local growers and packers
d. Farmers, produce and flea markets
e. Commercial haulers of host material
f. Public transportation
g. Post office contacts and
h. Canneries and other processing establishments.

5. Monitoring the movement of host material to landfills to ensure adequate disposal of regulated articles.

6. Monitoring the destruction of regulated articles to ensure adequate destruction of any life forms of BCA which may be present.

7. Monitoring the movement of regulated articles through airports and other transportation centers.

8. Notifying homeowners near detection sites of regulations.

9. Visiting pharmacies and other establishments which may handle citrus leaves for medicinal purposes.

H. Removing Areas from Quarantine

Areas placed under regulation may be removed from quarantine requirements after the BCA has been declared eradicated. Program management will identify areas to be removed when the equivalent of 3 months (12 weeks) has passed since the last specimen recovery. One month must have elapsed since the cessation of control activities. Notice of Quarantine Revocation will need to be published when areas are removed from quarantine requirements.

I. Orientation of Regulatory Personnel

Only trained or experienced personnel will be used initially. Replacement personnel will be trained by the individual being replaced.

J. Regulatory Records

Records will be maintained as necessary to carry out an effective, efficient, and responsible regulatory program.

IV. CONTROL PROCEDURES

As control procedures are developed, they will be made available to involved States. There will be no Federal involvement in direct control programs. If treatments selected or proposed are not in compliance with current pesticide labels, an emergency exemption will need to be obtained under Section 18, or 24C, special local need (SLN), of FIFRA, as amended.

Eradication of a BCA infestation in the continental United States may not be possible (Schoulties et al, 1987). The following provides approved procedures available for use in most situations. These procedures include biological, mechanical, and chemical controls. Local conditions will determine the most acceptable procedure or combination of procedures to achieve suppression, control or eradication.

A. Recommended Pesticides

The treatments prescribed are predicted on an adequate survey. At the initiation of a program, an evaluation of available insecticides for use on program operations will be made.

1. Dimethoate	3. Dicrotophos	5. Safers
2. Immidacloprid	4. Monocrotophos	6. Quinalphos
7. Pirimicarb	8. Nicotine Sulfate	

B. Selection of Options

The following options may be used in a decisionmaking process.

1. No action will be taken if an initial survey shows BCA to be established in a large contiguous area;

or

2. No action will be taken if an initial survey shows BCA to be present in a number of widely separate and discrete areas;

and

3. BCA does not appear to be in large numbers owing to various factors attributed to predation/parasites and/or climatological considerations. This statement does not apply if populational estimates are felt to be due to very recent (within one year) establishment of the BCA.

4. BCA appears to be in large numbers over an extensive area. Options related to Biological Control are applicable.

5. BCA appears to be in moderate numbers over a well-defined area. Options related to suppression and Biological Control are applicable.

6. BCA appears to be confined to a very small well-defined area. Options related to suppression and/or eradication are applicable.

C. No Action

Under this option, it will be concluded that BCA has firmly established itself in the country and that:

1. No amount of effort will be successful in eradicating it;

2. Regulatory and /or suppressive measures will not be worth it in terms of cost, owing to the area involved and/or the rate of spread;

3. On the basis of measurable ecological factors, that BCA will not be present in sufficient numbers in the environment to warrant control or suppression efforts.

4. Control of the BCA should be left to normal means of pest control and other resources utilized to find ways of controlling the diseases it may carry.

D. Approved Control/ Suppression Options

(Various combinations of treatments to achieve control and/or suppression, including parameters.)

E. Approved Control Treatments

The following is a list of suggested treatments that may be applicable under certain conditions. Addendum E lists certain additional treatments available in BCA infested countries which have proved to be effective.

1. Biological Insecticides

   a. Bacterial
   b. Viruses
   c. Nematodes
   d. Fungi

      (1). Vertalec

   This has been discontinued by Novo Biokontrol in the United States. (Farm Chemicals, 1992)

Apply as per directions at the highest possible rate given for that host. An exemption may be needed for outside applications. Extremely toxic to aphids and whiteflies, including BCA. (Rondon, et al, 1980)

(2). Cladosporium sp. (Samways & Grech, 1986)

Not available in the United States?

Apply 4 x 10^8 conida per ml as a spray in water with 0.1% Tween added as a wetting agent. Use as a cover spray, paying particular care to spray the shoots and the area immediately surrounding them. Repeat every two weeks as necessary.

e. Juvenile Hormones

(1). Kinoprene (ZR - 777) (Anon., 1976)

Discontinued 1985 by Zoecon Corp.(Farm Chemicals, 1992)

Apply at a rate of 0.1 to 0.13% to hosts. Extremely effective against homopterans.

2. Introduction of Exotic Natural Enemies.

This technique is being carried out by USDA, ARS. Several parasites have already been imported and are under study. The objective is to have successfully introduced exotic Predators/Parasites known to attack BCA established on existing citrus aphids across the Southern United States prior to the arrival of BCA on the mainland (Note: Addendum F.4, Predators and Parasites; Meyerdirk & Yokomi, 1993).

3. Augmentation of Predators/Parasites in infested area.

This technique is applied by mass rearing of the most highly efficient parasites or predators for mass release in infested areas. The use of Beneficial Insect Planes (BIP), a type of model airplane controlled by radio, may be utilized to release parasites with less mortality than with conventional airplanes. Such craft can cover a 50 acre field in 6-7 minutes (Anon., 1993).

Commercially available predators in the United States whose efficacy needs to be tested on BCA are:

a. <u>Aphelinus mali</u>
A parasitoid of the wooly apple aphid and the black citrus aphid (Stoezel, per. com.) among many others. (Farm Chem. Hand.)

b. <u>Aphidoletes</u> <u>typhlocybae</u>
A predatory midge which attacks all types of aphids. (Farm Chem. Hand.)

c. <u>Chrysoperia</u> <u>carna</u> and <u>C</u>. <u>rufilabris</u>
Two generalist predators.
(Farm Chem. Hand.)

d. <u>Diaretiella</u> <u>rapae</u> (For Grain Aphids?)
A parasite
(Farm Chem. Hand.)

e. <u>Hippodamia</u> <u>convergens</u>
A generalist predator
(Farm Chem. Hand.)

f. <u>Orius</u> <u>tristicolor</u>
Predator of eggs, etc.
(Farm Chem. Hand.)

4. Conservation of Predators/Parasites

This treatment refers to the conservation of natural enemies, native or introduced, through integrated procedures with highly selective predator/parasite friendly insecticides or techniques, biological insecticides, and cultural practices favoring predators and parasites.

a. Nursery Soil Treatment (After Milne, 1977)

Apply a 40% Emulsifiable Concentrate of Dimethoate at a rate of 0.1 m^2. Alternatively, dilute 0.5 ml ai in 250 ml of water and pour around the base of each individual plant. Repeat after 5-6 weeks.

b. Trunk Injection (After Buitendag and Bronkhorst, 1980)

Trunk injection of selected insecticides will effectively curtail the pest population attacking an injected host, while protecting the predator/parasite population, except those individuals which may feed on or parasitize poisoned pests.

This technique is effectively limited to backyard situations or small areas, owning to its labor intensive nature. Herbaceous hosts cannot be treated in this manner.

<u>Materials</u>

Dicrotophos or Monocrotophos 40% water soluble concentrate
20 ml disposable plastic syringes
Drill with 3.8 mm by 30 mm bit (minimum length)

Procedure

Drill 3.8 mm by 25 mm deep holes in the host, following the chart below.

Number of Syringes Needed	When Trunk Diameter 25 cm above Ground is:	When Trunk Diameter 25 cm above Ground is:	Amount of Insecticide in ml/tree is:
1	<50 mm	25 mm	0.5
2	50 mm to 75 mm	50 mm	1.25
4	75 mm to	100 mm	3.75
		125 mm	5.0
	175 mm	150 mm	7.5
6	175 mm>	200 mm	11.25
		250 mm	15.0

Prepare a locking hole in the syringes. This is a small hole drilled through and near the top of the cylinder when the plunger is 2/3 of the way out. The hole goes through both cylinder and plunger and is large enough to permit a nail to pass completely through the syringe.

Fill the syringe up to one third full (never more) with the <u>undiluted</u> insecticide; then fill it up completely with air.

The syringe is now ready for use. It is inserted with a turning action into the hole prepared for it. The air in it is then compressed with the plunger, which is then held in position by passing the nail through the locking hole.

Absorption takes only a few minutes. This process is quicker when the hole is drilled through the longitudinal ridges of the trunk.

NOTE: It will take approximately 3 minutes per person to fill four syringes and attach them to the tree, and only a few seconds to remove same, after absorption.

Treatment will be repeated every 4 - 6 weeks or following the advice of an advisory panel.

c. Band treatment (After Buitendag & Bronkhorst, 1986)

This treatment, consisting of the free application of insecticide to the tree trunk with a trunk applicator or paint brush, is obviously less selective and somewhat more likely to endanger a parasite/predator population. However, the area of application is still out of the way of most parasite/predator and prey activity.

<u>Materials</u>

Dicrotophos (Azodrin 400 g/l)
Azodrin fork applicator <u>or</u>
(figured)
Azodrin brush applicator
(figured)

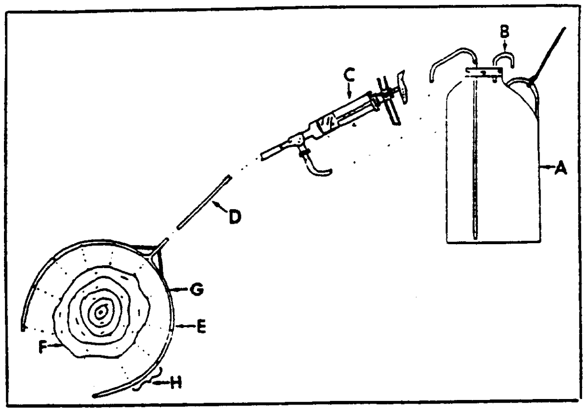


Figure 1: Azodrin trunk applicator for bearing trees.
A = Azodrin plastic container; B = Air inlet; C = 20 ml automatic syringe; D = 5 mm Diameter supply pipe; E = Spray fork; F = Tree trunk; G = 0.75 mm Orifice and H = 50 mm for small fork and 20 mm for large fork.

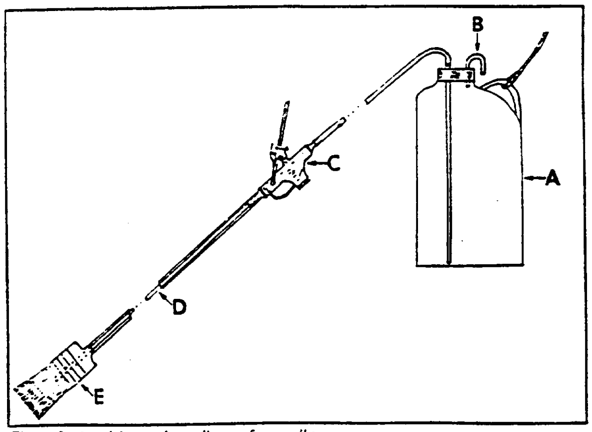


Figure 2: Azodrin trunk applicator for small trees
A = Azodrin plastic container; B = Air inlet; C = Stop valve; D = 5 mm Diameter supply pipe and E = Brush

Azodrin branch applicator

Figure 1

Azodrin brush applicator

Figure 2

<u>Procedure</u>

Spray or brush the required amount of undiluted Insecticide as given in the chart below. Cover the trunk with a wet band at the width given in the third column. Monthly treatments will be required.

Trunk Circumference in mm	ml of Azodrin Needed	Width of Azodrin Band in mm
30	0.1	9
40	0.15	13
50	0.3	16
100	0.8	32
150	1.0	48
200	2.8	64
250	4.8	80
300	6.5	96
350	10.0	111
400	15.5	127
450	24.0	143
500	35.0	159
550	50.0	175
600	70.0	191

5. Enablement of Predators/Parasites

This treatment refers to augmenting the ability of predators and parasites to attack the host with greater efficiency or to be more tolerant of insecticides or other practices through selective breeding of the most efficient predators/parasites. Gene manipulation may also be involved (Hoy, 1989, 1990; Caprio, et al, 1991). The work of Marjorie Hoy (now at the Univ. of Florida, Gainesville) in this area is instrumental to the concept and she should be consulted in designing any enablement program.

6. Ant Control

As an adjuvant to biological control options, ant control measures may be required to prevent ants from protecting the BCA from parasites and predators. There are several types of options, depending on the situation.

a. Backyard Hosts

Trees may be banded about 1 foot wide at the base of the trunks with an appropriately registered insecticide for ant control. There are a number of insecticides recommended for this use in the United States (Schwartz, 1982). These are:

Bendiocarb	Carbaryl	Chlorpyrifos	Dichlorvos
Diazinon	Fenthion	Lindane	Malathion
Propoxur	Pyrethrins		

In Brazil, it is recommended that dimethoate be sprayed on the trunk (Trevizoli & Gravena, 1978).

A recently developed South African control which avoids phytotoxic burns to the trunk is given below.

Bidim-plus-gladwrap Band

A 4 inch wide strip of Bidim U24 (a polyester fiber) is wrapped around the tree with an overlap of over an inch. It is then covered in turn with a double layer, 6 inch strip of Gladwrap. A 2 1/2 inch strip of Formex (a polybutene stickim) is then smeared over the masking tape, but not on the Bidim. (Samways & Tate, 1984)

This barrier has a half life of 18 weeks under South African conditions.

Hosts other than trees (such as soybeans) can not be treated directly, but ant mounds or nests on the premises should be treated with an appropriately registered insecticide for nest control.

b. Commercial Hosts

Broadcast application of an appropriately registered insecticide applied to the ground should be carried out. Under certain limited situations where the acreage is not too great, individual application to nests or mounds where ants are a problem may be employed.

7. Insecticides

a. Dimethoate

Apply only when host is in flush growth. Use as a full-cover spray in water, taking care to wet flush leaves. Do not use on rough lemon trees on non-budded lemon stock (Hill, 1975).

Note: Broad spectrum insecticide.

b. Immidacloprid

Apply whenever BCA is found as a foliar spray to hosts at the highest rate given for that host, or between 25 to 150 g/hectare a.i., at a biweekly rate (Mullins, 1993).

Note: Narrow spectrum insecticide with unknown effect on predators/parasites of BCA.

c. Safers

Apply whenever BCA is found as a foliar spray to hosts at the highest rate given for that host. Repeat every two weeks.

d. Malathion

Apply whenever BCA is found as a foliar spray to hosts at the highest rate given for that host. Repeat every two weeks. (Ware, 1980)

e. Nicotine Sulfate

Apply whenever BCA is found as a foliar spray to hosts at the highest rate given for that host. (Ware, 1980)

f. Quinalphos

Apply whenever BCA is found as a foliar spray to hosts at the highest rate given for that host. (Shevale, 1987)

Note: Wide-spectrum insecticide with unknown effects on parasites and predators of BCA.

g. Pirimicarb

Apply whenever BCA is found as a foliar spray to hosts at the highest rate given for that host. In Brazil, this rate is 0.025 kgm ai/1000 citrus trees.

Note: Relatively selective insecticide which spares some of the predators, vis, <u>Chrysopa</u> sp. and <u>Cycloneda sanguinea</u> in Brazil. Used in an integrated control program with dimethoate sprayed on the tree trunks to control ants (see 6.a below) (Portillo, 1975; Trevizoli & Gravena, 1979).

h. CGA-215944

Apply whenever BCA is found as a foliar spray to hosts at the highest rate given for that host. A novel and still experimental insecticide in a new class. Very selective for aphids and relatively nontoxic to predators. About four times as effective as Primicarb. This insecticide may not yet be registered in the United States (Fluckiger, C.R., et al., 1992).

8. Cultural Treatments

a. Sticky Ribbons

Sticky plastic ribbons (yellow or blue) for control of (among other pests), aphids. (Farm Chem. Hand.)

b. Yellow Sticky Strips/Traps

Plastic yellow sheets coated with an insect trapping compound for control of aphids. (Farm Chem. Hand.)

c. Water Spray

Application of a strong jet of water spray to dislodge and injure as many aphids as is possible. Work all around the host plant, if possible, directing the spray at tender flush where aphids will most likely be found. (see Shevale, et al, 1987; Samways & Grech, 1986; for examples of the effectiveness of water sprays)

A nontoxic liquid soap could be added to the water to increase its effectiveness, but no studies have been carried out on this possibility.

F. Approved Eradication Options	(Various combinations of treatments to achieve eradication, including parameters.)
G. Approved Eradication Treatments	(List of Treatments and how applied.)
H. Orientation of Control/ Eradication Personnel	Only trained and experienced personnel will be utilized initially. Replacement personnel will be trained by the individual being replaced.
I. Eradication/ Control Records	Records noting the locations, dates, number and type of treatments, and materials and formulations used will be maintained for all areas treated.

J. Monitoring

An effective monitoring program will be implemented to aid in the evaluation of program efforts and environmental impact. The application of pesticides will be assessed through the use of appropriate monitoring program criteria. The evaluation must effectively address Agency, cooperator, and public concerns.

The program plan should include at least the following elements:

1. Determine the efficacy of any pesticide used against the target pest.

2. Evaluate dye needs to monitor aerial applications, especially;

    a. Droplet size
    b. Droplet distribution
    c. Identification of drift components
    d. Verification of spray block boundaries
    e. Identification of skips

3. Sampling to evaluate the effect of a MALFF program on the environment will be conducted in accordance with a Environmental Monitoring Plan. These plans include pre and post application sampling and observations to determine the impact on soil, water, vegetation, and non-target species. Carcass searches are a part of this monitoring.

V. CONTACTS

When a BCA program is implemented, its success will depend on the cooperation, assistance, and understanding of many involved groups. The following groups should be continually informed of all operational phases of an emergency program.

1. Federal, State, county, and municipal agricultural officials

2. Grower groups

3. Commercial interests

4. Universities

5. State and local law enforcement officials

6. Public health

7. Foreign agricultural interests

8. National, State, and local news media, and

9. The general public.

VI. PATHWAY EVALUATION

A. Natural Means

Spread, by alates and carried by wind currents in the upper atmosphere. This has the potential to carry BCA over hundreds of miles. The alates have the ability to efficiently find suitable hosts in the area where they find themselves (Roistacher & Bar Joseph, 1987). However, introduction by natural means is said to be unlikely (EPPO, 1992; Gottwald, 1993), a position which is in dispute.

B. Travel & Commerce

Only fresh leaves and young stems appear to present a risk. Leaves are transported illegally for medical reasons by individuals. Citrus fruit, unless young (EPPO, 1992), is not a host for BCA (Reeves, 1992). However, the status of mature fruit or the fruit or pods of other hosts is not known.

BCA is more strongly attracted to yellow than are many other aphids and it may therefore be transported on yellow packaging or aircraft parts. (EPPO, 1992)

It has been very infrequently intercepted in the USA on citrus from Hawaii and the Philippines. Introduction of BCA through plants brought in for planting and associated materials is said to be much more likely than through natural means (EPPO, 1992: Gottwald, 1993). Again, this is an area where serious disagreement exists.

VII. ADDENDA

Addendum A--Definitions

Aerial Treatment:	Applying an insecticide by aircraft over a treatment area.
Array:	The trapping pattern in the delimiting survey area located around a detection.
Array Sequence:	The intensity of traps within an array, beginning with the core area and continuing outward through each buffer area, ending with the outer buffer area.
Buffer Area:	The area extending a prescribed distance beyond the boundary of the core, the 1-, 2-, 3- and 4-mi buffers.
Commercial Production Area:	An area where host material is grown for wholesale or retail markets.
Confirmed Detection:	A positive laboratory identification of a submitted life form (specimen) as BCA.
Core Area:	The one square mile area surrounding any confirmed BCA detection.
Day Degrees:	An accumulation of heat units above a developmental threshold.
Delimiting Survey:	Determining whether an infestation exists and if so, the extent of the infestation in an area where the BCA has been detected.
Detection:	The collection of any life stage of BCA.
Detection Survey:	An activity to determine the presence of BCA, conducted in a susceptible area not known to be infested.
Developmental Threshold:	The minimum (or maximum) temperature below (or above) which physiological development stops (peaks).
Epicenter/Focal Point:	The initial site of an infestation.

Eradication:	The confirmed removal of all BCA life forms in a specified geographical area, as determined by a negative survey for 3 months (12 weeks) or the equivalent of at least 6 life cycles.
Fumigation:	The application of an approved fumigant (Methyl Bromide) as a treatment alone, to hosts.
Generation: (Life Cycle)	The period of time required for the pest to complete all stages of development.
Ground Spray:	Using ground spray equipment to apply an insecticide to the above-ground parts of host vegetation in a BCA infested area.
Host:	A plant species capable of supporting BCA reproduction.
Infestation:	The collection of one or more life forms of BCA or the detection of a single specimen determined to be associated with a current infestation.
Infested Area:	A distance of 1 1/2 miles from all detection sites unless biological factors indicate the need for more or less area.
Monitoring/Evaluation Survey:	Using interdependent visual and perhaps trapping surveys in an area where a control or eradication treatment is in progress to evaluate the effectiveness of the application.
PPQ-APHIS-USDA:	Plant Protection and Quarantine, Animal and Plant Health Inspection Service, U.S. Department of Agriculture.
Regulated Area:	An area that extends at least 4 1/2 miles in all directions from an infested property.
Regulated Articles:	All known or suspected hosts of BCA or any other suspected product or article.
Regulatory Inspection:	Visual examination of host material and containers at establishments where regulated articles are grown, handled, processed, or moved. Under some circumstances this can include discretionary trapping around selected establishments.
<u>Toxoptera</u> <u>citricida</u>: (Kirkaldy)	The scientific name of the brown citrus aphid.

Trap Survey:	Determining the presence or absence of a pest by the use of traps placed in a predetermined pattern and serviced on a given schedule.
Urban/Residential Area:	An area containing multiple or single family dwellings, and/or commercial and industrial facilities.
Visual Survey:	Examining hosts for eggs, nymphs and adults, either in the field or in regulated establishments, or in monitoring the movement of regulated articles.

Addendum B--Safety

Personal and public safety must be a prime consideration at all times. Safety practices should be stressed in preprogram planning and through the duration of actual program operations. Supervisors must enforce on-the-job safely procedures.

Addendum C--Hosts

Common Name		Scientific Name
Various		*Citrus* spp.
Trifoliate-orange		*Poncirus trifoliata*
Kumquats		*Fortunella* spp.
		Severinia buxifolia
		Cudrania tricuspidata
Japanese persimmon		*Diospyros kaki*
Fig, common		*Ficus carica*
Pear		*Pyrus communis*
		Toddalia asiatica
		Trema orientalis
Rhododendron	(Hosts from Denmark, 1978)	*Rhododendron* spp.
Azalea	(Anon., 1957)	*Rhododendron* spp.
Soybean	(Halbert, et al, 1986)	*Glycine max* Merr.
		Evodia hupehensis
Cotton	(Anon., 1957)	*Gossypium hirsutum*
	(Anon., 1938)	*Murraya exotica*
	(Yokomi, 1992)	*Xanthoxylum* sp.
Mango	(Australian Quarantine)	*Mangifera indica*
		Calodentrum capense
		Choisya ternata
		Cotoneaster sp.
Australian desert lime		*Eremocitrus glauca*
		Flindersia xanthoxyla
		Geijera parviflora
		Maclura cochinchinensis
Bermuda buttercup		*Oxalis pes-caprae*
English elm		*Ulmus procera*
	(Carver, 1978)	*Vepris undulata*

BCA is recorded as having hosts in 21 families of plants (Raychaudhuri, 1980). This needs to be verified.

Addendum D--Technical Survey Information

1. Cross Transit Survey

Draw two straight lines on a map that will intersect each other and run through:

- High Risk suburban/urban areas whose residents are likely to travel to BCA infested areas.
- Citrus Production Areas
- Areas where Citrus is in abundance (Backyards, etc.)
- Coastal areas where Citrus is available.

The lines should both bisect the area under survey. They do not need to be perpendicular to each other, but should both run through the most suitable local sites that have been identified.

2. Survey Procedures

a. When Citrus is in New Flush

(1) Examine all Citrus along the transit. If there are many trees along the transit (as in a grove), select 1 out of ten trees. A minimum sample along any one transit should be 10 trees.

(2) Restrict examination to Citrus, especially Citrus with new growth. In particular, pay attention to new growth that appears stunted or retarded or otherwise abnormal in appearance; and of trees which appear to be unhealthy.

(3) Knock aphids, if any, into a wide mouth jar with alcohol; or onto a light-colored cloth sheet such as a beating (insect) umbrella from which aphids (if any), can be put quickly into a vial or bottle with alcohol.

(4) Label sample with the exact location, the date, and the collectors name in enough detail so that someone else can find the spot.

(5) Send vials (bottles) in to a designated center for identification/processing.

b. When Citrus is not in New Flush

(1) Examine the undersides of mature foliage for dead, parasitized aphids or mummies. As these adhere to the leaves, they can be used for identification in the absence of living specimens (EPPO, 1992).

(2) Examine all secondary or reservoir hosts along the transit. This includes backyard and field or wild cotton, Azalea, Granadilla and other hosts that are relatively easy to examine.

(3) Follow the procedures as given above.

The survey should be run weekly or biweekly until it is determined, through negative finds, that BCA is not present in a given area. Transit lines may be moved in the judgement of the survey officer responsible for that area, in an attempt to cover more favorable hosts or new locations.

3. Inspection Procedures

During periods of low aphid populations and mobility, visual surveys and aids are better employed. Traps may be deployed when aphid populations are high or flight times are estimated to peak at a given time.

a. Survey of new flush on hosts. Look for distorted and faded terminal growth, and colonies of aphids. This technique is best in the spring.

b. Honeydew, sooty mold, and ant trails. These signs may be checked throughout the year.

c. Beating sheet. Use a beating sheet under suspect hosts to detect light infestations.

(CDFA Detection Manual- D.T. 3:29)

d. Green pan traps (Halbert et al, 1986). These traps are for use in hosts with a low canopy such as soybean or cotton fields.

Traps are of clear plastic sandwich boxes, each with a green tile ceramic within and filled with water. They are mounted at canopy level with double ended clamps and support stands. Traps are to be serviced every day and water is to be changed at least once a week.

e. Yellow sticky traps. These traps may be used in hosts with a high canopy, such as Citrus. In this situation, yellow is a better attraction for BCA on a year round basis, as it is never less attractive than green and may be up to 10 times as attractive during the growing season (Schwarz, 1965).

f. Moericke yellow trays. (Carver, 1978; Seif & Islam, 1988) These traps may be used in hosts with a high canopy, such as Citrus.

Traps are of 25 cm diameter plastic bowls, painted yellow inside and black outside. They are filled with water up to two small outlets below the rim. A few drops of formaldehyde are added to preserve the catch. The outlets are covered with plastic gauze to prevent the trapped insects from being washed out during heavy rains. The traps need to be serviced as frequently as necessary to maintain the water level, but should be serviced at least weekly.

Each trap is suspended 6 and 1/2 feet (two meters) above the ground or as necessary to be in line with the host canopy. In general, they should not be hung from a host, but near it, on a post or pole in the open. Approximately 4 traps per quarter acre have been used to track BCA populations.

g. Suction traps (Carver, 1978). Suction traps are not currently recommended for BCA, owing to an extremely low capture rate as compared to yellow tray traps and to their comparatively great cost per trap. The capture ratio in one study was 61:4 and in another, 1417:1, both in favor of the yellow tray (Taylor, et al., 1972). A trap design described as an "inexpensive suction trap" cost $300.00 in 1987 and required 20 man-hours of labor for construction and erection (Allison and Pike, 1988). It is possible that a suction trap design incorporating yellow as part of its attraction could be developed and deployed in such a way that a few traps could cover a large area, but this is not now available.

NOTE: The yellow used will greatly affect both the size of the sample and its species composition. Deciding which yellow to use may be complicated, because manufacturers use different bases and pigments to produce colors which appear the same to humans, but not to aphids. For that reason, different species of aphids may react differently to two different yellows. This is of concern in a survey for one specific aphid, in this case BCA. BCA is (Taylor, et al., 1972) one of the species most strongly attracted to yellow. Apparently, Canary Yellow (British Standard Prime Yellow, B.S. 0-001) will elicit the best response from BCA. This color corresponds to Munsell Colour 5.0 Y 9/14 and R.H.S. Colour Chart Yellow Group 9A. This color is made with titanium oxide and has a standard spectral response curve (Taylor, et al., 1972).

Addendum E--Technical Control Information

The following control data specifically refers to control measures for BCA on Citrus in selected countries. Extremely hazardous insecticides are not included.

Australia (Dept. Primary Industry, 1976)

Demeton-S-methyl	Apply as a spray at a concentration of 0.02 to 0.025%. The withholding period is 21 days.
Dimethoate	Apply as a spray at a concentration of 0.02 to 0.05%. The withholding period is 7 days. Do not use on kumquat, meyer lemon or seville orange.
Maldison	Apply as a spray at a concentration of 0.05 to 0.06%. The withholding period is 3 to 7 days.
Methomyl	Apply as a spray at a concentration of 0.02%.
Pirimicarb	Apply as a spray at a concentration of 0.025%. The withholding period is 14 days.
Thiometon	Apply as a spray at a concentration of 0.02%. The withholding period is 21 days.

South Africa (Bot, et al, 1983)

Chlorpyrifos	Use 20 ml of an emulsifiable concentrate of 480 gms ai/litre in 100 litres of water. The withholding period is 60 days.
Demeton-S-Methyl	Use 80 ml of an emulsifiable concentrate of 250 gms ai/litre in 100 litres of water. Apply to nursery stock only.
Dimethoate	Use 100 gms of a wettable powder of 200 gms ai/Kgm in 100 litres of water, or Use 40 ml of an emulsifiable concentrate of 400 gms ai/litre in 100 litres of water. The withholding period is 14 days. Do not spray rough lemon or seville orange.
Endosulfan	Use 300 gms of a wettable powder of 475 gms ai/kgm in 100 litres of water. The withholding period is 10 days. Will not interfere with the effectiveness of Aphytis africanus (a parasite of red scale) or induce outbreaks of red mite when used as recommended. Not for home use.

Addendum F--Life History

1. Systematic Position

Brown Citrus Aphid, *Toxoptera citricida* (Kirkaldy) (Homoptera, Aphididae)

Class : Insecta
Order : Homoptera
Family: Aphididae

The BCA is one of five species in *Toxoptera*. The genus is considered to be Far Eastern in origin, but two species, BCA and *T. aurantii* are widely distributed (Blackman & Eastop, 1984). *T. aurantii* (Black Citrus Aphid) occurs in the United States, including Maryland and California, and throughout much of the rest of the World, including England, Belgium, and Japan among temperate areas (CIE, 1961). *T. odinae* is found in Asia and Africa. and the two other species, *T. schlingii* and *T. victoriae* come from Hong Kong (Stoetzel, 1992). BCA has a wide distribution which is somewhat more restricted than the Black citrus aphid, being absent from arid areas (CIE, 1961).

BCA is a species first described from Hawaii, but thought to originate in China (Denmark, 1978). With the help of man, it has spread to tropical and temperate areas of Asia, Africa, Australasia, many Pacific Islands including Hawaii, and South America since the 1930's to Central America and to the West Indies, including Puerto Rico, more recently.

2. Identification Characters

Toxoptera	A stridulatory apparatus of ventral-lateral ridges on the abdomen and peg like hairs on the hind tibiae distinguishes this genus from *Aphis* (Blackman & Eastop, 1984).
Apterous (wingless) Female	Small to medium size aphids, 1.5 - 2.4 mm in length and oval in shape. Mostly shiny dark brown or black: Head black or dark brown; Antennae 6 segmented, with very long hairs (Blackman & Eastop, 1974), antennal segments I, II, VI and the tips of segments IV and V may get progressively darker to black or dark brown towards tips, III without secondary sensoria; the thorax is dark brown or black; dark brown or black lateral and dorsolateral spots are present on the abdomen. Cornicals elongate and black, heavily and spinulosely imbricated. Cauda elongate, with 21-40 setae, black. The genital plate, anal plate, coxae, the tips of the femora, the bases and tips of the tibiae, and all of the tarsae are dark brown or black. The femoral hairs are very long and numerous. The ventral-lateral abdominal stridulatory reticulation is extensive, uniformly lightly serrated and sclerotised, closely transverse and inconspicuous. (Carver, 1978; Denmark, 1978; Stoetzel, 1990)

Alate (winged) Female	Size 1.1-2.6 mm in length, oval. Similar in color overall. Antennae 6 segmented; with 7-20 secondary sensoria on antennal segment III, this completely dark, other segments may have apical bands, especially segment IV (Stoetzel, 1992), segment IV has 0 - 5 secondary sensoria. The cauda is black, elongate, broad at the base and parallel-sided in the distal half with 21 - 40 setae. The cornicals are elongate, tapering, imbricated, black, and almost twice as long as the cauda. The antennal and body setae are short and pointed. Forewing with a pale pterostigma; median wing vein branched twice. (Denmark, 1978; Blackman & Eastop, 1984; Stoezel, 1990)

3. <u>Biology</u>

Reproduction is primarily vivparous and parthenogenetic. Colonies are exclusively female and each mature female produces many clutches of live nymphs, which are all females. Males and mating is not necessary. The young nymphs require about 12 days for maturity.

Reproductive potential depends on the abundance of plant sap; ranging from more than 47 nymphs laid in 12 days to less than 22 nymphs laid in 20 days (EPPO, 1992).

The nymphal and prereproductive periods of alatae take significantly longer in development at 20 (11.3 and 12.7 days) and 25°C (7.1 and 7.6 days) than apterae, whose development periods are 10.3 and 10.6 days and 6.5 days (for both life stages) at those temperatures respectively. Interestingly, the age specific fecundity (average number of eggs laid) of apterae is consistently higher than that of the alatae. The apterae have a net higher reproductive rate (61.2 at 20°C and 62.5 at 25°C) than the alatae (42.4 at 20°C and 45.9 at 25°C). The capacity for an increase in the population is therefore higher for apterae (0.205 at 20°C and 0.352 at 25°C) than for the alatae (0.176 at 20°C and 0.287 at 25°C)(Takanashi, M., 1989).

Generally, about 30 generations may develop annually, depending on the temperature (EPPO, 1992).

These aphids are found on the young soft terminal leaf growth, tender stem bark, flower buds and young fruit of the host(Stoetzel, 1992; Carver, 1978; EPPO, 1992). It does not naturally feed on hard, mature leaves (Carver, 1978). In heavy infestations, severe leaf deformation, which results in leaves becoming brittle, wrinkled and curled downwards (EPPO, 1992), as opposed to <u>T. aurantii</u>, which does not cause this distortion. Attacked flowers fail to open or do so abortively, since the ovaries are deformed (EPPO, 1992). This direct feeding also results in honeydew production and sooty mold develops. The leaf distortion causes severe restrictions in growth of shoots and fruit setting is affected. In severe cases, a host can die.

Colonies on <u>Citrus</u> are more abundant in the spring and early summer, when new flush is present. Alates develop intermittently (Anon. 1957) as each colony increases, and serve to disperse the population (Denmark, 1978). Alates may also be produced when crowding occurs and nutritional resources are in short supply. As far as is known, there is an influx of immigrants to host plants in the spring and an outgo of emigrants in the summer for other hosts (with more abundant tender growth at that time?) (Komazaki, 1981). They are carried long distances in the upper winds and can efficiently find suitable hosts on which to feed and establish colonies (Roistacher & Bar-Joseph). Flight frequency is correlated with rainfall. During a flight period, there are usually two daily flight peaks, occurring about 9 to 11 in the morning and another from 5 to dusk in the evening (EPPO, 1992).

In China, there seems to be a single peak flight period in mid-August (late summer) (Halbert, et al, 1986). This was also reported from Kenya in June/July (Seif & Islam, 1988). However, there may also be a flight peak in the spring as well (Leppla, 1992), and in Australia there are two flight periods in Spring and Autumn, with about 85% of the catch at traps at these times (Carver, 1978). In Japan, BCA populations actually peak two to three times a year. The first is from late May to early June, the second is in middle to late August and the last is from mid to late September. In some years the second or third peak disappears (Komazaki, 1981). Since aphid populations may increase about a month after a rainfall if the host plants produce new flushes of growth (Seif & Islam, 1988), this may explain part of the reason for many of the observations in the literature. However, this is only a condition for aphid population increases and other factors may be involved (Komazaki, 1981).

The temperature and humidity requirements of BCA are not completely known. However, some studies have been carried out. At threshold temperatures of 46.4 °F in unshu orange and 47.15 °F in sour orange, no development takes place at all. At a minimal developmental temperature of 52.34 °F in sour orange, there is a mean generation time of 43 days, a survival rate of 85.1%, a long prereproductive period of about 35 days, a longevity period of almost 72 days, and a net reproductive rate of about 25 per female. At optimum temperatures, which for sour orange is 70.7 °F, the mean generation time is shortened to just over 12 days, the survival rate is over 90%, the prereproductive period is just under 9 days, the longevity is about 24 days, and the net reproductive rate is nearly doubled to 51 per female. In unshu orange the optimum temperature is about 77 °F with somewhat higher rates of increase. Lethal temperatures are 85.46 °F in unshu orange and not determined for sour orange, but probably near 31 °F. It should be noted that at 85.82 °F, BCA was still active and had a short mean generation time of just 8+ days. However, the net reproductive rate was only 3.87 per female (Komazaki, 1982). It is also evident that the host has some influence on these parameters, and suggests, in this case, that BCA is more closely adapted to unshu orange than to sour orange. This may be characteristic of a species with a narrow host range (Komazaki, 1982).

Other information (Nickel & Klingauf, 1985) indicates that maximum and minimum temperatures for BCA are 95 °F and 57.2 °F respectively, a range of from 30 to 95% relative humidity and a light intensity between 9 - 12000 Lux. Optimal temperatures were recorded at 73.4 °F ± 5.6°,with a relative humidity between 40-80% and about 3000 Lux.

BCA apparently does not occur in drier citrus producing areas such as the Mediterranean region. This is supported by studies in India which show that BCA populations increase during hot and humid weather in July and August, decline in Sept/October (due to other factors), reach the highest levels in December and January, even though the temperature has dropped to 62.6 °F but conditions are still humid, and then drop to almost nil in Feb/March, even though the temperature has again gone up (to 82.4 °F) but conditions are dry (Koli, et al, 1981). However, these observations could be due to luck and circumstances rather than to natural limits. In Australia, BCA is reported in inland, semi-arid irrigated regions and is known to have some effect on crop yield to the extent that this is under study in South Australia (Maelzer, 1979). It should be noted that cultivation and/or the establishment of urbanized areas in semiarid or arid zones result in extensive modification of the local climate which could be amenable to BCA.

There is some indication that BCA can tolerate cold weather to some extent, since it is found in Japan, Korea and New Zealand as well as in tropical areas (Stoetzel, 1992). In fact, it may apparently tolerate colder conditions than _T. aurantii_, since it occurs at higher altitudes (Blackman & Eastop, 1984). Generally, where these two aphids occur together, BCA is the predominant aphid species infesting citrus over _T. aurantii_, and although the latter is commonly present, it utilizes other diverse food-plants (Carver, 1978). In addition, under winter conditions, BCA deposits overwintering eggs, in a lower density than other aphid species, on a more limited range of hosts. This results in early spring increases in the population of BCA on these hosts, whereas the eggs of other overwintering aphids are scattered among more diverse hosts (Komazaki, 1979, 1981, 1982). By the same token, the restricted availability of hosts and the apparent low density of overwintering eggs may also limit BCA dispersal to a wide area the following spring, until much later in the season than the dispersal of other aphid species (Komazaki, 1981).

The BCA serves as a primary vector of several plant diseases. These include Citrus Tristeza Virus (CTV) in numerous forms (stem pitting, lime dieback, citrus yellows) and Soybean Mosaic Virus (SMC) (Halbert, et al, 1986). It is a very efficient vector of CTV, as only low populations of BCA can rapidly transmit the disease. In fact only 4 hours of feeding by a single aphid is sufficient for effective acquisition of the virus, and under certain circumstances 1 hour is enough (Roistacher & Bar-Joseph, 1987). For maximum effectiveness of viral transmission, 24 hours is enough. In China, viral transmission of SMC takes place during a peak flight time in mid-August.

In addition to the above, BCA is able to transmit the mosaic viruses of abaca, pea, yam, and Chili veinal mottle virus (Blackman & Eastop, 1984). This raises the question of if these crops are also hosts of BCA.

4. Predators and Parasites

Predators

Predators generally arrive when aphid populations are rapidly increasing in numbers, but the increase in predators lags behind that of the aphids. This is a typical pattern, one in which the predators arrive too late or leave too early to be true regulators of aphid populations. (Yokomi, ms)

There are many predator records on BCA, especially in the Coccinellidae and Syrphidae. A partial listing is given below.

Coccinellidae

Cycloneda sanguinea L. - Lady beetle (Morales & Burandt, 1985)
(Rondon et al, 1980)
(Note: may not be suitable predator)
Most effective predator in Misiones, Argentina (Nickel & Klingauf, 1985)
Effective predator in Brazil and survives Primicarb applications (Trevizoli & Gravena, 1979)

Coccinella repanda Thnb. (Carver, 1978)

Scymnus hilaris Motschulsky (Komazaki, 1981)

Especially mentioned by Komazaki.

Many species listed by Yokomi, ms.

Syrphidae

Simosyrphus grandicornis (Macq.) (Carver, 1978)

Many species listed by Yokomi, ms.

Chamaeymiidae

Leucopis sp. (Carver, 1978)

Leucopis puncticornis ? - (Yokomi, ms)

Chrysopidae

Ankylopteryx octopunctata ? - (Yokomi, ms)

Chrysopa sp. (Trevizoli & Gravena, 1979)

Cited as surviving Primicarb spray applications in an integrated control scheme.

Chrysopa formosana ? - (Yokomi, ms)

Chrysopa septempunctata ? - (Yokomi, ms)

Chrysopa signata Schneider (Carver, 1978)

Mallada boninensis ? - (Yokomi, ms)

Hemerobiidae

Micromus timidus ? - (Yokomi, ms)

??

Harmonia conformis (Boisd.) (Carver, 1978)

Melangyna viridiceps (Macq.) (Carver, 1978)

Ocyptamus gastroctactus (Wiedemann) (Rondon, et al, 1980)

Zelus sp. (Rondon, et al., 1980)

Parasites

There are two different groups of aphid parasites, based on their morphology and behavior. Both groups are in the Hymenoptera (Wasps) and both have good potential as biocontrol agents.

The Braconids are less host specific than the Aphelinids. They form mummies out of their aphid host.

The Aphelinids have some advantage for biocontrol purposes in that they are more host specific and can act as predators, since the adult feeds on aphid body fluids obtained by wounds made through ovipositional punctures. This feeding is necessary for oogenesis (egg maturation). Aphelinids turn their aphid host into black, dead bodies (Yokomi, ms).

Braconidae

Aphidius colemani ? - (Yokomi, ms)

Most effective parasite in Misiones, Argentina (Nickel & Klingauf, 1985)

Aphidius smithi ? - (Yokomi, ms)

Binodoxys indicus ? - (Yokomi, ms)

Binodoxys scutellaris ? - (Yokomi, ms)

Imported by APHIS for studies in 1991. (Meyerdirk & Yokomi, 1993)

Lipolexis gracilis ? - (Yokomi, ms)

Lysiphlebus delhiensis ? - (Yokomi, ms)

Lysiphlebus japonica Ashmead - (Takanashi, 1990)
(Note: Successful control may depend on morph & age distribution of a host colony at time of the attack.)

Lysiphlebus testaceipes ? - (Yokomi, 1992)
Positive identification pending. This and Aphelinus gossypii may have the most potential for biological control. Imported by ARS for evaluation in 1992. (Meyerdirk & Yokomi, 1993)

Trioxys communis ? - (Yokomi, ms)

Aphelinidae

Aphelinus colemani Vier. (Carver, 1978)
Rarely found.

Aphelinus gossypii Timb. - (Yokomi, 1992)
Common parasite (Carver, 1978)
Imported by APHIS from China for evaluation. (Meyerdirk, 1993)

Aphelinus mali ? - (Yokomi, 1992, ms)

5. Entomopathogens

Dueteromycetes

Fungi

Cladosporium sp. nr. oxysporum (Beck. & Curt.) - (Yokomi, ms)
Observed in the field on BCA in South Africa.
Laboratory trials in the field had considerable initial impact.
(Samways & Grech, 1986)

Verticillium lecanii ? - (Yokomi, ms)
Commercially used against Aphis gossypii in greenhouses in Europe and observed in the field on BCA in Venezuela.

Group ??

Paecilomyces fumosoroseus ? - (Yokomi, ms)

Paecilomyces sp. - (Yokomi, ms)

Beauveria bassiana ? - (Yokomi, ms)

Metarhizium anisopliae ? - (Yokomi, ms)

Aschersonia sp. ? - (Yokomi, ms)

Cephalosporium sp. ? - (Yokomi, ms)

Entomophthorales

Empusa fresenii ? - (Yokomi, ms)

Pandora neoaphidis ? - (Yokomi, ms)

Pandora nouryi ? - (Yokomi, ms)

Pandora delphacis ? - (Yokomi, ms)

Viruses

Rhopalosiphum padi virus
Found in some aphids. (Yokomi, ms)

Aphid lethal paralysis virus (Yokomi, ms)

5. Natural Protection

Ants

Some species of ants will protect BCA or are potential predators. Ants have been associated with BCA (Carver, 1978) and it is said that the colonies are usually visited by ants (EPPO, 1992). In Japan, Pristomyrmex pungens apparently protects BCA against predators (Shindo, 1972). The Imported fire ant (IFA), Solenopsis geminata (F.) exists in high numbers in some areas where the BCA may establish itself. Should the IFA turn out to protect BCA from parasites and predators, this could result in greater BCA populations (anon., 1992). Other common ant species could have the same net result.

Addendum G--Identification of Specimens

As many specimens as possible of the pest are to be collected for screening/identification by the local designated identifier.

Addendum H--Forms

Forms, as developed by the State, may be listed in this section.

Addendum I--Contributors

To Be Filled In

Addendum J--References

Allen, R.P., 1972. Brown Citrus Aphid. Toxoptera citricida. D.T. 3:29. Detection Manual, Exclusion and Detection. CDFA, Division of Plant Industry, 2pp.

Allison, D. and Pike, K.S., 1988. An Inexpensive Suction Trap and its Use in an Aphid Monitoring Network. J. Agric. Entomol. 5(2):103-107.

Anonymous, 1938. Food Plant Catalogue of the Aphids of the World. The Maine Agricultural Experiment Station, Orono, Maine. Bull. 393:161.

Anonymous, 1957. Oriental black citrus aphid, Aphis citricidus (Kirkaldy). INKO, CEIR, 7(38): 33-34.

Anonymous, 1961. Pest: Toxoptera citricidus. Distribution Maps of Pests, Series A (Agricultural), Dec., 1961. C.I.E., 56 Queen's Gate, London, Map No. 132: 2 pp.

Anonymous, 1961. Pest: Toxoptera aurnatii. Distribution Maps of Pests, Series A (Agricultural), Dec., 1961. C.I.E., 56 Queen's Gate, London, Map No. 131: 2 pp.

Anonymous, 1976. Preliminary Experiments on the Application of Juvenoids in the control of Agricultural Insect Pests. Acta Entomologica Sinica, 19(3):263-281.

Anonymous, 1992. The Day of the Fire Ants. Michigan Today, October, 1992: p. 13.

Anonymous, 1993. 85-Beneficial Insect Planes. In: New Products. Ag Consultants, 49(5):p. 18.

Blackman, R.L. and Eastop, V.F., 1984. Aphids on the World's Crops. An Identification Guide. John Wiley & Sons, New York, pp. 364-366.

Bot, J., Sweet, S. and Hollings, N., 1983. A Guide to the Use of Pesticides and Fungicides, 26th Revised Edition. Republic of South Africa, Department of Agriculture, Government Printer, Pretoria, :pp. 62-63.

Buitendag, C.H. and Bronkhorst, G.J., 1980. Injection of insecticides into tree trunks--a possible new method for the control of citrus pests? Citrus & Subtropical Fruit Journal, March, 556:5-7.

Buitendag, C.H. and Bronkhorst, G.J., 1986. Insecticides: Phytotoxicity, side effects on incidental pests, and development of application apparatus. Citrus & Subtropical Fruit Journal, February, 623:7-11.

Caprio, M.A., Hoy, M.A. and Tabashnik, B.E., 1991. Model for implementing a genetically improved Strain of a Parasitoid. American Entomologist, 37(4):232-239.

Carver, M., 1978. The black citrus aphids, Toxoptera citricida (Kirkaldy) and T. aurantii Boyer de Fonscolombe. J. Australian Ent. Soc., 17(3):263-270.

Denmark, H.A., 1978. The brown citrus aphid, Toxoptera citricida. Entomology Circular No. 194, Florida Dept. Agric. & Consumer Serv., Div. Plant Industry, 2 pp.

Department of Primary Industry, 1976. Uses of Insecticides in Australia 1974. Australian Government Printing Service, Canberra: p. 91.

EPPO, 1992. Quarantine Pests for Europe. Data Sheets on Quarantine Pests: Toxoptera citricidus. CAB International, University Press, Cambridge, :329-333.

Fluckiger, C.R., et al., 1992. CGA-215944. A Novel Agent to control Aphids and Whiteflies. Proceedings, Brighton Crop Protection Conference, Pests and Diseases, 1992 Brighton, Nov., 23-26, 1992, pp. 43-50.

Gottwald, T.R., 1993. CTV: Where is the Bad Stuff and How Did it Get There? Citrus Tristeza/Brown Citrus Aphid Workshop, Lake Alfred, Florida, April, (In Press).

Halbert, S.E., Zhang, G. and Pu, Z., 1986. Comparison of sampling methods for alate aphids and observations on epidemiology of soybean mosaic virus in Nanjing, China. Ann. Appl. Biol., 109: 473-483.

Hill, D.S., 1975. Agricultural Insect Pests of the Tropics and their Control. Cambridge Univ. Press, Cambridge, London,: pp. 150-151.

Hoy, M.A., 1990. Genetic Improvement of Arthropod Natural Enemies: becoming a Conventional Tactic? Proceedings of a UCLA Colloquium held at Frisco Colorado, 1989. Alan R. Liss, New York, 112: 405-417.

Hoy, M.A., 1990. Genetic Improvement of Parasites and Predators. FFTC-NARC International Seminar on the use of parasitoids and predators to control Agricultural Pests, Tukuha Science City, Japan, :15pp.

Koli, S.Z., Maker, P.V. and Choudhari, K.G., 1981. Seasonal Abundance of Citrus Pests and their Control. Indian J. Ent., 43(2):183-187.

Komazaki, S., Sakagami, Y. and Korenaga, R., 1979. Overwintering of Aphids on Citrus Trees. Jap. J. appl. Ent. Zool., 23(4):246-250.

Komazaki, S., 1981. Life Cycles and Population Fluctuations of Aphids on Citrus. Proc. Int. Soc. Citriculture, 2:692-695.

Komazaki, S., 1982. Effects of Constant Temperatures on Population Growth of Three Aphid Species, Toxoptera citricidus, Aphis citricola and Aphid gossypii on Citrus. Appl. Ent. Zool. 17(1): 75-81.

Maelzer, D.A., 1979. The current status of the Biological Control of Insect Pests of Citrus in Australia. Australian Applied Entomological Research Conference, Queensland Agricultural College, Lawes. CSIRO, Canberra:236-240.

Meyerdirk, D.E. and Yokomi, R.K., 1993. Proposal - Biological Control of the Brown Citrus Aphid. USDA. DRAFT: pp. 1-6.

Milne, D.L., 1977. Control of citrus nursery pests by soil applications of Dimethoate. Citrus & Subtropical Fruit Journal, 525:5-7.

Morales, J. and Burandt, C.L., 1985. Interactions between Cycloneda sanguinea and the Brown Citrus Aphid: Adult Feeding and Larval Mortality. Environ. Entomol., 14: 520-522.

Mullins, J.W., 1993. Imidacloprid: A New Nitroguanidine Insecticide. Newer Pest Control Agents and Technology with Reduced Environmental Impact. American Chemical Society Symposium. (In Press)

Nickel, O. and Klingauf, F., 1985. Biologie und Massenwechsel der Tropischen Citrus-Blattlaus Toxoptera citricidus in Beziehung zu Nutzlingsaktivitat und Klima in Misiones Argentinien. Entomol. Gener., 10(3/4):231-240.

Portillo, M.M., 1975. Accion del afidicida Pirimicarb en el pulgon de los Citrus Toxoptera citricidus, y en el coccinelido predator Cycloneda sanguinea. Idia, 331/333:63-66.

Raychaudhuri, D.N., 1980. Aphids of North-East India and Bhutan. The Zool. Soc. (India), Calcutta, pp. 74-78.

Reeves, D., 1992. In: Minutes of the APHIS Brown Citrus Aphid Stakeholder Workshop. Ladner, D.R., APHIS. Various pp.

Roistacher, C.N. and Bar-Joseph, M., 1987. Aphid transmission of Citrus Tristeza Virus: A Review. Phytophylactica, 19:163-177.

Rondon, A., Arnal, E. and Godoy, F., 1980. Comportamiento del Verticillium lecanii (Zimm.) Viegas, Patogeno del Afido Toxoptera citricidus (Kirk.) en Fincas Citricolas de Venezuela.

Samways, M.J. and Tate, B.A., 1984. Evaluation of several trunk barriers used to prevent the movement of the pugnacious ant into citrus trees. Citrus & Subtropical Fruit J., Sept.:9-26.

Samways, M.J. and Grech, N.M., 1986. Assessment of the Fungus Cladosporium oxysporum as a potential biocontrol agent against certain Homoptera. Agric. Ecosystems and Environ., 15(4):231-239.

Schoulties, C.L., et al, 1987. Citrus Tristeza Virus and Vectors: Regulatory Concerns. Proc. Fla. State Hort. Soc., 100:74-76.

Schwarz, R.E., 1965. Jahreszeitliche Schwankungen im Verhalten von Toxoptera citricidus Kirk. gegnuber gelben Anlockungsmitteln. Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz. 72(2):84-89.

Schwartz, P.H., 1982. Guidelines for Control of Insect and Mite Pests of Foods, Fibers, Feeds, ornamentals, Livestock, and Households. USDA, ARS, Agric. Handbook No. 584, 734 pp.

Seif, A.A. and Islam, A.S., 1988. Population Densities and Spatial Distribution Patterns of _Toxoptera citricida_ in Citrus at Kenya Coast. Insect Sci. Applic., 9(4):535-538.

Shevale, B.S., et al, 1987. Studies on Relative Efficacy of Certain Insecticides against Citrus Aphid, _Toxoptera citricida_. Pestology, 11(4):9-10.

Shindo, M. 1972. Relation between ants and aphids in a citrus orchard. Proc. Assoc. Pl. Prot. Kyushu, 18:69-71.

Stibick, J.N.L., 1992. _Toxoptera citricida_ (TCA) Survey for Puerto Rico. USDA, APHIS, PPQ, : pp. 1-8.

Stoezel, M.B., 1990. Some Aphids of Importance to the Southeastern United States. Florida Entomologist, 73(4):580-586.

Stoezel, M.B., 1992. In: Minutes of the APHIS Brown Citrus Aphid Stakeholder Workshop. Ladner, D.R., APHIS. Various pp.

Taylor, L.R. and Palmer, J.M.P., 1972. Aerial Sampling. In Aphid Technology by van Emden H.F. Academic Press, New York, pp.189-234.

Takanashi, M., 1989. The reproductive ability of apterous and alate viviparous morphs of the citrus brown aphid, _Toxoptera citricidus_. Jap. J. Appli. Entomol. Zoo. 33(4):266-269.

Takanashi, M., 1990. Development and reproductive ability of _Lysiphlebus japonicus_ Ashmead parasitizing the citrus brown aphid, _Toxoptera citricidus_ Kirkaldy. Jap. J. Appli. Entomol. Zoo. 34(3):237-243.

Trevizoli, D. and Gravena, S., 1979. Eficiencia e Seletividade de Inseticidas para Controle Integrado do Pulgao Preto dos Citrus _Toxoptera citricidus_. Cientifica, 7(1):115-120.

Ware, G.W., 1980. Complete Guide to Pest Control with and without Chemicals. Thomson Publ., Fresno, Calif. Various pp.

Yokomi, R., 1992. In: Minutes of the APHIS Brown Citrus Aphid Stakeholder Workshop. Ladner, D.R., APHIS. Various pp.

Yokomi, R., ms. Potential for Biological Control of _Toxoptera citricidus_ (Kirkaldy). ms: 4 pp.